

# Analysis of the effect of sludge loading on phosphorus removal in SBR wastewater treatment system

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**Abstract.** Based on SBR we discussed on biological removal phosphorus system. In the reaction temperature at 15°C and 25°C under the conditions of influent COD/TP ratio and COD load of sludge. Total phosphorus concentration of influent was be constant for 10 ± 0.5mg / L, compared to anaerobic paragraph at the end of the water and TP concentration. The results showed that: ① Under both temperature conditions the effluent TP concentration is reducing with the influent COD/TP ratio increase, especially when the influent COD/TP ratio is more than or equal to forty, the effluent TP concentration is below 1 mg/L. ② Two temperatures with the COD load of sludge was risen from the effect to reduce the concentration of TP, when the sludge COD load ≥ 0.46mgCOD/mgMLSS • d, the effluent TP concentration was lower than 1mg / L; ③ In reaction temperature of 25°C and 15°C, the amount of anaerobic releasing paragraph and COD load of sludge are very good correlation, linear relationship between the two were:  $y = 0.72 + 71.91 x$  (25°C),  $y = 2.81 + 73.33 x$  (15°C); ④ In the COD load of sludge under the same conditions, the removal rate in 15°C is higher 5% than the one in 25°C; ⑤ The effluent of aeration rate on the phosphorus removal efficiency of SBR system was investigated, which showed that the aeration rate was an important factor affecting the activity of poly. Increasing the aeration rate will greatly increase the phosphorus uptake efficiency of the phosphorus accumulating bacteria, and increase the phosphorus removal efficiency.

## Introduction

New craft of phosphorus (P) removal has been developed duo to release/attracts the An/O process、PhoStrip process、VIP process、A<sup>2</sup>O process、Bardenpho process、UCT process and SBR process etc. However, its effect usually limited to many factor which regardless of what form processing craft by P removal principle, including reaction temperature, DO in the aerobic/ anaerobic paragraph, sludge age, NO<sub>3</sub>—N concentration in the anaerobic paragraph, Nutrition ratio of influent with reaction temperature and COD load of sludge being the main biological removal phosphorus factor. Hence this paper dedicates to a detailed discussion based on An/OSBR craft to it.

## Materials and methods

### A Experimental

All of the laboratory scale models used in this work (Fig.1) were made of plexglass. The size of the An/OSBR was: 40 cm height, 10 cm diameter and the base bagger is the frustum shape. The useful volume of the reactor was divided into four discrete compartments of equal height (10 cm). Every compartment was equipped with ports for the sampling of liquid, as well as it was outlet of wastewater. The reactor was installed pipe with sludge. the air supply was the porous stone as the pore waterfall propose, such as Phosphate Accumulating Organisms) had phosphorus principle of PAOs (Poly by air compressor with drum wind aeration way. Reactor is fixed the mixer, and its user maintain spate mix evenly when non-aeration condition or aeration quantity is less.

All experiment were done in a temperature control changer with a temperature of 25°C. And it were monitored in unceasingly a variation of DO, ORP and the pH value in the reaction process with

appropriate transducer. Sludge age ( $\theta_c$ ) of process are control about 10 days. Until use, the MLSS were kept at 2500mg/l.

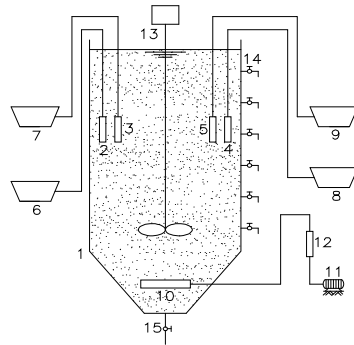


Fig.1.The configuration of An/OSBR process

1—Reactor; 2—pH transducer; 3—DO transducer;4—ORP transducer;5—temperature transducer; 6—pH cryoscope; 7—DO cryoscope; 8—ORP cryoscope; 9—temperature controller; 10—Aeration head; 11—air compressor; 12—flow meter; 13—mixing; 14—sampling; 15—outlet of sludge

### B Wastewater and sludge

The influent fed into the full-scale reactor was the municipal wastewater generated intermixture of beer wastewater and protein peptone. In addition, inorganic nutrients also are essential,  $\text{NaHCO}_3$  for alkalinity of solution, and  $\text{NH}_4\text{Cl}$  for density of ammonia nitrogen, and  $\text{KH}_2\text{PO}_4$  for density of water phosphate, and inorganic elements such as calcium, magnesium, may also be required for PAOs growth. Minor nutrients is necessary to growth of active sludge microorganism. Ingredient and figures of simulation wastewater are identified in Table 1.

Experimental vaccination sludge come from returned sludge of secondary deposit chamber of MUCT process in experiment. It had been start by simulation municipal wastewater at 2007.10. After ten weeks later ,it is stable for removal phosphorus effect in system and then sampling and determination.

Table1 Components of simulational wastewater and feature of water quality

Components of simulational wastewater		Minor factor		Quota of water quality	
Medical preparation	Throws the increment / $\text{g}\cdot\text{L}^{-1}$	Compose	Concentration/ $\text{g}\cdot\text{L}^{-1}$	Iitem	Concentration/ $\text{mg}\cdot\text{L}^{-1}$
Beer wastewater	1.5~3.5mL/L	$\text{FeCl}_3$	0.9	COD	200~500
Peptone	0.1	$\text{H}_3\text{BO}_4$	0.15	BOD	118~315
$\text{NH}_4\text{Cl}$	0.1	$\text{CoCl}_2\cdot 7\text{H}_2\text{O}$	0.15	TN	23.5±1
$\text{KH}_2\text{PO}_4$	0.044	$\text{CuSO}_4\cdot 5\text{H}_2\text{O}$	0.03	$\text{NH}_4^+\text{-N}$	21.1±0.8
$\text{NaHCO}_3$	0.16~0.8	KI	0.18	$\text{NO}_3^-\text{-N}$	< 1
$\text{CaCl}_2$	0.01	$\text{MnCl}_2\cdot 4\text{H}_2\text{O}$	0.06	$\text{NO}_2^-\text{-N}$	< 1
$\text{MgSO}_4$	0.05	$\text{Na}_2\text{Mo}\cdot 2\text{H}_2\text{O}$	0.06	TP	10.0±0.5
Minor factor liquid	0.6mL/L	$\text{ZnSO}_4\cdot 7\text{H}_2\text{O}$	0.12	pH	6.9~7.1

### Examination project and method

Supernatant of water sample was determination by centrifugal; COD was determination by fast detector of 5B-1; TP was determination by molybdenum-antimony anti-spectrophotometric;  $\text{NH}_4^+\text{-N}$  adopt Nessler 's reagent spectrophotometry;  $\text{NO}_3^-\text{-N}$  adopt thymol spectrophotometry;  $\text{NO}_2^-\text{-N}$  adopt N- (1-naphthyl) -ethylenediamine spectrophotometric method; MLSS was determination by filter paper weight; SVI was determination by standard method (SV30/MLSS).

Discussion

Fig2 shows that the variation of effluent TP concentration and TP recovery rate under different COD/TP ratio conditions at the reaction temperature 25°C and 15°C. The content of anaerobic P-release was calculated with balancing of materials. When the influent COD/TP ratio is equal to or greater than forty, the effluent TP concentration is below 1mg/L and the TP recovery rate is more than 90%, that is to say the SBR process has high phosphorus removal efficiency. When the influent COD/TP ratio is less than or equal to 35, the effluent TP concentrations are high both at reaction temperature 25°C and 15°C, so the TP recovery rate are lower than 84.7% and 88.6%.

TP (total phosphorus) Concentration and elimination rate of TP was indicated in Fig.3 in different sludge load in reaction temperature 25°C and 15°C. And the amount of anaerobic releasing paragraph which gained by the mass balance in the anaerobic was indicated in Fig.3 in different sludge load in reaction temperature 25°C and 15°C. It is obvious that TP concentration lower than 1mg/L and elimination rate above 90%, SBR process may acquire ideal phosphorus removal effect, under the condition of COD load of sludge  $\geq 0.46\text{mgCOD}/\text{mgMLSS}\cdot\text{d}$ . And when COD load of sludge  $\leq 0.40\text{mgCOD}/\text{mgMLSS}\cdot\text{d}$  and reaction temperature is 25°C and 15°C, the throughput of total phosphorus of effluent is high and elimination rate is lower than 84.7%、88.6% separately.

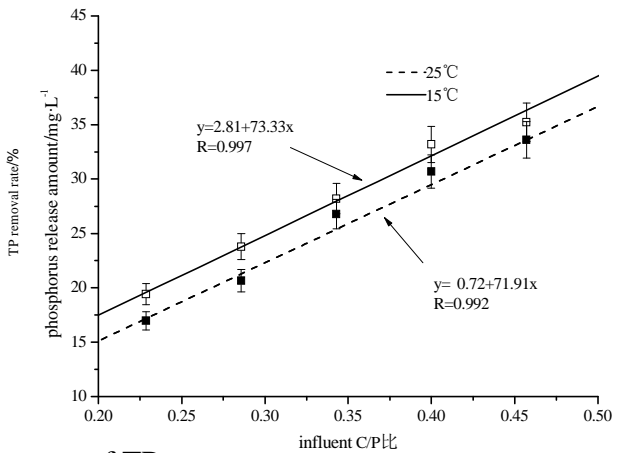
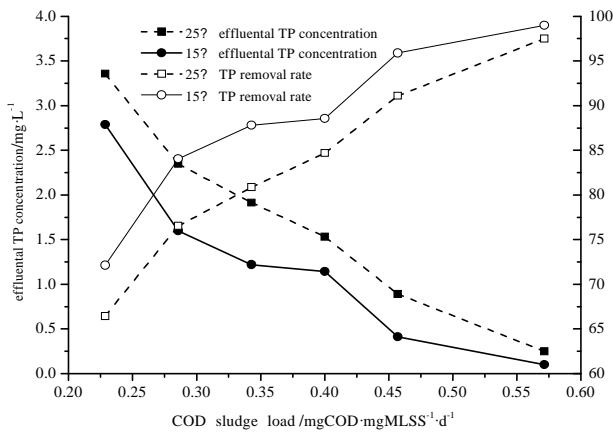


Fig.2 Relation between COD load and elimination rate of TP Fig.3 Relations both COD load

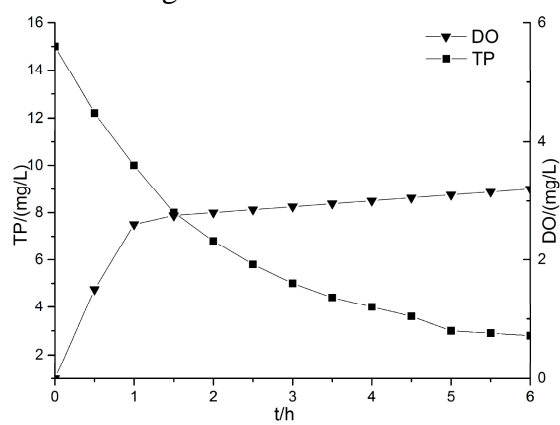
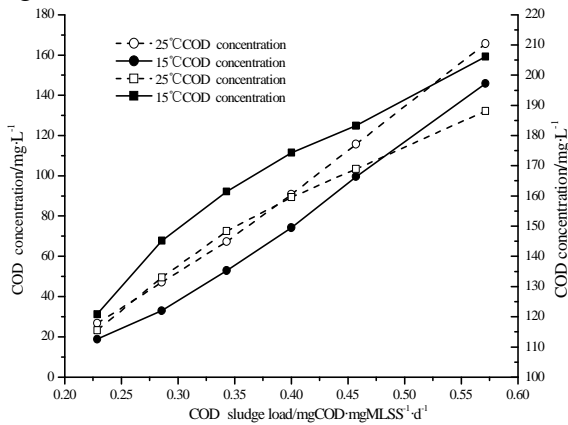


Fig.4 Express relation between concentration of COD in the anaerobic segment Fig.5 The relation of TP and DO changes over the time

It is obvious in Fig.4 that throughput of phosphorus in anaerobic segment was increased when COD sludge load rise. According to basic principle we may infer that consumption of COD in anaerobic segment was absorbed by PAOs and then stored interior by PHB for using the PAOs excessive attracts the phosphorus in later aerobic segment. After data fitting we find out that there are a good relevance between throughput of phosphorus and COD sludge load when reaction temperature of 25°C and 15°C. And two group of data tally with the following function relationship:

$$y=0.72+71.91x. \tag{1}$$

$$y=2.81+73.33x. \quad (2)$$

And X represent COD sludge load, Y represent throughput of phosphorus.

It can be seen from Fig. 4 that with the increase of the aeration rate, the oxygen transfer rate increases and the DO of the SBR system increases. At the same time, the rate of uptake of phosphorus by anaerobic bacteria also increased accordingly. It can be seen from the figure, DO close to 4mg / L, phosphorus removal effect is good and stable.

Fig.5 express relation between concentration of COD in the anaerobic segment and consumption of COD. When the biomass almost maintains at 2500mg/L, and has the same numbers of PAOs, we may find out that consumption of COD in the anaerobic section was increased along with increasing of COD load of sludge It indicate that storage capacity of PHB in the anaerobic segment no only decided by number of PAOs but also decided by concentration of COD, and more COD lead to advantageous to the PHB storage, larger reserves. That is to say throughput of PHB under the condition of anaerobic incomplete depend on energy which providing by hydrolysis high energy phosphoric acid key.

We may draw the conclusion from Fig.3、 Fig.4 and Fig.5 that TP elimination effect at 15°C is higher about 5% than temperature is 25°C, when COD load of sludge is the same. When COD load of sludge was 0.46mgCOD/mgMLSS·d and reaction temperature was 25°C, now concentration of TP was 0.89mg/L,remove rate of TP was 91.1%, throughput of phosphorus in anaerobic segment was 33.61mg/L , concentration of COD in the later anaerobic segment was 115.76mg/L and consumption of COD was 168.94mg/L; Simultaneously, when reaction temperature was 15°C, and then concentration of TP was 0.41mg/L, remove rate of TP was 95.88%, throughput of phosphorus in anaerobic segment was 35.23mg/L, concentration of COD in the later anaerobic section was 99.56mg/L and consumption of COD was 183.31mg/L. Its reason is as follows: ① The accumulation of content in vivo of certain microorganism depend on temperature deeply, a companying with rising in temperature and then throughput of PHB was reduced. ② Minor of PAOs is addicted to the warm fungus and major of PAOs is addicted to the cool fungus, therefore, they holds the superiority when temperature was 20°C or slightly low temperature condition. According to this experiment result we may know the high temperature will affect to eliminate the phosphorus effect in the system. In order to overcome this question, it is necessary that the system carries on temperature abate processing or the guarantee system carbon source is sufficient.

The variation of e COD load of sludge has the slight effect upon remove rate of COD during experiment period, in system remove rate of COD was about 90%,and 65%~85% COD in the anaerobic segment was consumption.

## Conclusions

(1)When the influent COD/TP ratio is more than or equal to 40, the effluent TP concentration is below 1mg/L at 25°C and 15°C in An/OSBR reactor, the phosphorus recovery rate is more than 90%, so the An/OSBR has high phosphorus removal efficiency. When the influent COD/TP ratio is less than or equal to 35, because carbon is shortage, the TP recovery rate is low under both conditions, and the effluent TP concentration is more than 1mg/L.

(2)When COD load of sludge $\geq$ 0.46mgCOD/mgMLSS·d, regardless of reaction temperature was 25°C or 15°C, concentration of TP in the effluent all lower than 1mg/L, remove rate was above 90%,SBR process may obtain ideal effect upon remove rate of phosphorus; When COD load of sludge $\leq$ 0.40mgCOD/mgMLSS·d, because lacks the carbon source lead to remove rate of COD was low, and concentration of TP was higher than 1 mg/L.

(3)Throughput of COD in the anaerobic segment and COD load of sludge existence good relevance, and they cater for linear relationship, respectively is  $y=0.72+71.91x$  ( 25°C ) ,  $y=2.81+73.33x$  ( 15°C ) .

(4) When there is a same COD load of sludge, remove rate of COD at 15°C was higher than 25°C above 5%, moreover, throughput of phosphorus and consumption of COD in the anaerobic section in system also higher.

(5) The effect of aeration rate on the phosphorus removal efficiency of SBR system was investigated, which showed that the aeration rate was an important factor affecting the activity of poly. Increasing the aeration rate will greatly increase the phosphorus uptake efficiency of the phosphorus accumulating bacteria, and increase the phosphorus removal efficiency.

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